TRIFUNCTIONAL REAGENT FOR CONJUGATION TO A BIOMOLECULE

Ins A1

Field of Invention

The present invention is directed to a reagent for the conjugation to a biomolecule for the diagnosis and treatment of human and animal conditions or diseases.

More precisely, the present invention is generally directed at a novel chemical reagent which simultaneously conjugate an affinity ligand and an effector agent with a biomolecule to obtain minimal modification of that biomolecule; a method of conjugation and radiolabeling with the new reagents; and application of the modified biomolecules to diagnosis and therapy of a human or animal condition or disease. As an example, chemical reagents which contain an affinity ligand (e.g. a biotin moiety), an effector agent (e.g. a radiolabeling moiety), and a biomolecule reactive moiety are coupled together through a trifunctional cross-linking moiety and spaced apart with linker moieties. Using such a reagent, a biomolecule can be biotinylated and radiolabeled via one of two methods, then employed in medical protocols, such as those utilizing extracoporeal immunoabsorptive removal methods to minimize the toxic effects to normal tissue and blood components.

Background of the Invention

Many biomolecules, including proteins and peptides, hold potential as reagents for use in diagnosis and therapy of human conditions and diseases. As most biomolecules do not, by themselves, have properties to make them useful as diagnostic and/or therapeutic reagents, biomolecules of interest are often chemically modified to achieve this. However, one very important criterion must be applied when chemically modifying biomolecules. That criterion is that the modification does not alter the biological property that is important (e.g. cancer cell targeting) in the use of that particular biomolecule.

This criterion makes it imperative that site-selective (where possible) and minimal modification of the biomolecule be conducted.

Modification of a targeting biomolecule with an effector agent, such as a radionuclide, can provide valuable new tools for diagnosis and therapy of human and animal diseases or conditions. Coupling of a radionuclide to the biomolecule results in the desired diagnostic effect of providing photons that can be measured or imaged externally to show the localization of the radiolabeled biomolecule, or it may provide the desired therapeutic effect of causing damage to cells or tissues that are targeted by the biomolecule. Biomolecules labeled with photon emitting radionuclides can be used for the diagnosis of a number of human conditions (i.e. extent of myocardial infarcts, presence of cancer, etc.). For example, technetium-99m labeled antibodies can be used to diagnose cancer (Granowska et al. Eur. J. Nucl. Med. 20, 483-489, 1993; Lamki et al. Cancer Res. 50, 904s-908s, 1990; Goldenberg et al. Cancer Res. 50, 909s-921s, 1990); iodine-123 labeled fatty acids can be used to evaluate myocardial perfusion (Corbett J. Nucl. Med. 35, 32s-37s, 1994; Hansen J. Nucl. Med. 35, 38s-42s, 1994; Knapp et al. J. Nucl. Med. 36, 1022-1030, 1995); and fluorine-18 labeled fluorodeoxyglucose can be used to evaluate a variety of functions of the brain (Posner et al., Science 240, 1627-1631, 1988). Biomolecules labeled with particle emissions (e.g. beta, positron, alpha, Auger electrons) can potentially be used for targeted radiotherapy of human disease such as cancer. For example, a large number of monoclonal antibodies (Behr et al. J. Nucl. Med. 38, 858-870, 1997; Divgi et al. J. Nucl. Med. 36, 586-592, 1995; DeNardo et al. Anticancer Res. 17, 1735-1744, 1997) and peptides (Zamora et al. Int. J. Cancer 65, 214-220, 1996; Stolz et al. Digestion 57, 17-21, 1996; Bender et al. Anticancer Res. 17, 1705-1712, 1997) labeled with

therapeutic radionuclides such as iodine-131, yttrium-90 and Re-188 are being investigated as new reagents for cancer therapy. Thus, an important modification that can be carried out is to attach a functional moiety to the biomolecule which binds or bonds with a radionuclide. For small (i.e. < 2000 Da molecular weight) biomolecules, usually only one radionuclide binding/bonding moiety is site-selectively attached to cause minimal perturbation in its desired biological properties. Larger biomolecules, such as peptides and proteins, may be conjugated with more than one radionuclide binding/bonding moiety before loss of the desired biological properties, but these molecules generally retain more of their desired biological properties when minimal number of conjugations are obtained.

Modification of biomolecules with an "affinity ligand" is also important as it provides a means of coupling two entities together for a variety of *in vitro* and *in vivo* applications. By their nature, affinity ligands come in pairs. The preferred affinity ligands used for coupling to the biomolecule must have a high enough binding constant (e.g. 10^6 M^{-1} or greater) with a second compound to allow the two coupled entities to remain together for a period of time. An example of an affinity ligand pair is a monoclonal antibody and its hapten. The affinity ligand pairs of biotin/avidin and biotin/streptavidin are often used with biomolecules. The very strong interaction (i.e. $K = 10^{13} - 10^{15}$ M^{-1}) of biotin with the proteins avidin and streptavidin (Green, Methods Enzymol. 184, 51-67, 1990; Green, Adv. Prot. Chem. 29, 85-133, 1975) provides a foundation for their use in a large number of applications, both for *in vitro* and *in vivo* uses. While the proteins avidin and streptavidin are sometimes conjugated with biomolecules, conjugation of biotin introduces less perturbation of the biomolecule, and more than one biotin molecule can be conjugated with minimal

affect on the biomolecule. Therefore, the preferred affinity label is biotin or a derivative thereof, and the examples herein are reflective of this preference. As with the radionuclide binding/bonding moiety, it is important to minimize the number of affinity ligands (e.g. biotin conjugates) attached to a biomolecule to retain the desired biological properties.

Modification of the biomolecule by attachment (conjugation) of another molecule to a particular reactive functional group (e.g. amine, sulfhydryl, aldehyde, ketone) precludes attachment of a second molecule to that group. Thus, if attachment of more than one type of molecule to a biomolecule is desired (to impart two functions), the attachment must be made at a second site using currently available reagents. Since in some applications, it is desirable to have both an affinity ligand and an effector agent (e.g. a moiety that binds/bonds with a radionuclide), site-selective conjugation is precluded. Further, modification of biomolecules that are not made in a site-selective manner (e.g. reaction with surface amine groups in proteins) are limited due to the fact that two different sites are modified. Additionally, modification of larger biomolecules (e.g. proteins) in two subsequent steps can result in a heterogeneous population of modified biomolecules in which molecules that contain the second conjugated species may have less of the desired biological properties (i.e. tumor targeting) than those that do not contain the second conjugate. This can result in a subgroup of biomolecules containing both conjugated species that do not have the properties desired. To circumvent these problems, the affinity ligand (e.g. biotin moiety) and an effector agent (e.g. radionuclide binding/bonding moiety with or without the radionuclide) can be coupled together through trifunctional cross-linking reagent to form a new type of reagent. With the use of this new class of reagents, an equal number of

affinity ligands and radionuclide binding/bonding moieties will be conjugated to the biomolecule. With a combined affinity ligand and radiolabeling compound, site specific addition of both reagents can be made, and minimization of the number of conjugates to the biomolecule can be attained. Linking an affinity ligand such as biotin to a fluorescent moiety which is further attached to an oligosaccharide is described in Varki et al., WO 94/28008. The issue of attaching an affinity ligand to cytotoxic agent or an agent which can convert a prodrug to an active drug, and where either of these are further attached to a targeting molecule, is addressed in Nilsson et al., US patent application 08/090 047. However, none of these publications neither alone or in combination describe or indicate the present innovation. The issue of combining an affinity reagent and effector agent on one molecule to achieve minimal modification of biomolecules is not unique to biotin (as the affinity ligand) or radionuclide binding/bonding moieties (the effector agent), and is not limited to only one affinity ligand and one effector ligand per molecule. Combinations of more than one affinity ligand and/or more than one affinity ligand per molecule may be advantageous for certain applications.

The radiolabeled and affinity ligand conjugated biomolecule products obtained from this invention are useful in many *in vitro* and *in vivo* applications. A preferred application, where the biomolecule is a tumor binding monoclonal antibody, toxin conjugate, or enzyme conjugate, the affinity ligand is biotin or a derivative thereof, and the radionuclide is a diagnostic or therapeutic radionuclide used in a patient cancer treatment protocol, is to use a biotin binding (e.g. avidin coated) column for extracorporeal immunoabsorptive removal of a radiolabeled antibody conjugate from a patient's blood. Extracorporeal removal of the radiolabeled antibody,

toxin conjugate, or enzyme conjugate limits the toxic effects of the radioactivity, toxin, or enzyme to specifically targeted tissues, minimizing the exposure time and interaction with non-target tissues. Importantly, to be effective, medical agents (e.g. biomolecules) must exert their pharmacological action on a particular target tissue or group of target cells. Targeting of such agents is most often carried out by systemic administration (i.e. intravenous injection) which means that they will be transported through the blood and lymph system to most parts of the body. This transportation, or circulation, of the medical agent throughout the body can result in undesirable toxic side effects in tissues or organs other than those where the effect of the agents is beneficial to the patient.

Specific tissue or organ localization of a medical agent is a very important factor in its effective application. Lack of specific tissue localization is of particular importance in the treatment with medical agents where the desired effect is to kill certain types of cells such as in the treatment of cancer. In order to increase the specificity and thereby make the cancer therapy more effective, tumor marker specific targeting agents such as cancer cell binding monoclonal antibodies have been used as carriers for various cell toxic agents (immunoconjugates) such as, but not limited to, radionuclides, cytotoxins, and enzymes used in prodrug protocols (Meyer et al., Bioconjugate Chem. 6, 440-446, 1995; Houba et al., Bioconjugate Chem. 7, 606-611, 1996; Blakey et al., Cancer Res. 56, 3287-3292, 1996). Although, monoclonal antibodies are selectively bound with tumor cells over non-tumor cells, an initial high concentration of the toxic immunoconjugate is required to optimize binding of a particular agent with tumors in a patient. While required for optimal therapy of the cancer, the high concentration of cytotoxic material in blood and non-target

tissues causes undesirable side-effects on sensitive and vital tissues like the bone marrow. Various methods have been proposed to rapidly clear these agents from blood circulation after that the tumor has received a maximum dose of the immunoconjugate. Some blood clearance methods involve the enhancement of the bodies own clearing mechanism through the formation of various types of immune complexes. Similarly, blood clearance can be obtained by using molecules that bind with the immunoconjugate, such as monoclonal antibodies (Klibanov et al., J. Nucl. Med. 29, 1951-1956, 1988; Marshall et al., Br. J. Cancer 69, 502-507, 1994; Sharkey et al. Bioconjugate Chem. 8, 595-604, 1997), (strept)avidin (Sinitsyn et al., J. Nucl. Med. 30, 66-69, 1989; Marshall et al., Br. J. Cancer 71, 18-24, 1995), or biotin containing compounds which also contain sugar moieties recognized by the asialoglycoprotein receptor on liver cells (Ashwell and Morell, Adv. Enzymol. 41, 99-128, 1974). Other methods involve means of removing the circulating immunoconjugates through extracorporeal methods (see review article by Schriber G.J. & Kerr DE, Current Medicinal Chemistry, 1995, Vol. 2, pp 616-629).

The extracorporeal techniques used to clear a medical agent from blood circulation is particularly attractive. Extracorporeal devices for this application have been described (Henry CA, 1991, Vol.18, pp.565; Hofheinz D et al, Proc. Am. Assoc. Cancer Res. 1987 Vol. 28, pp. 391; Lear JL, et al. Radiology 1991, Vol.179, pp.509-512; Johnson TK, et al. Antibody Immunoconj. Radiopharm. 1991, Vol. 4, pp.509; Dienhart DG, et al. Antibody Immunoconj. Radiopharm. 1991, Vol. 7, pp.225 ; DeNardo GL, et al. J. Nucl. Med. 1993, Vol. 34, pp. 1020-1027 ; DeNardo GL, et al. J. Nucl. Med. 1992b, Vol. 33, pp. 863-864; DeNardo S.J., et. al. J. Nucl. Med. 1992a, Vol. 33, pp. 862-863. U.S. Patent Number 5,474,772; Australian patent 638061, EPO 90 914303.4 of Maddock, describe these methods.

To make the blood clearance more efficient and to enable processing of whole blood, rather than blood plasma, the medical agent (e.g. tumor specific monoclonal antibody carrying cell killing agents or radionuclides for tumor localization) have been biotinylated and cleared with the use of an affinity (e.g. biotin-binding) column. A number of publications provide data which show that this technique is both efficient and practical for the clearance of biotinylated and radionuclide labeled tumor specific antibodies (Norrgren K, et al. Antibody Immunoconj Radiopharm 1991, Vol. 4, pp. 54 ; Norrgren K, et. al. J. Nucl. Med. 1993, Vol. 34, pp. 448-454 ; Garkavij M, et. al. Acta Oncologica 1996, Vol. 53, pp.309-312; Garkavij M, et. al. J. Nucl. Med. 1997, Vol. 38, pp. 895-901). U.S. Patent application No. 08/090,047, EPO 92 903 020.3 of Nilsson and 08/434,889 of Maddock describe these applications.

Summary of the Invention

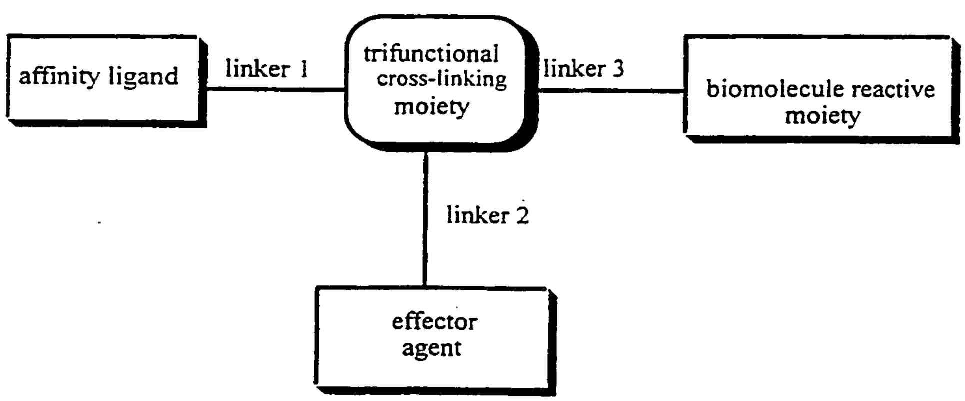
The object of the present invention is to eliminate the above mentioned problems in the art. This object is achieved with a reagent as described by way of intruduction and having the features defined by the characterising part of claim 1. Preferred embodiments are presented in the subclaims.

In general, the invention discloses a new type of compound which combines an affinity ligand and an effector agent in a single molecule that can be used to modify biomolecules. The modified biomolecules are themselves new entities in that fewer sites on them are modified than obtainable with previous reagents. More specifically, the invention describes the chemical components and examples of a new type of molecule (shown in schematic structure (I)) that can be used to conjugate an affinity ligand, such as biotin, and concurrently conjugate an effector ligand, such as a radionuclide binding/bonding moiety with/without a radiolabel, to a bio-

molecule of interest for a variety of diagnostic and therapeutic applications. This invention also discloses two approaches to the attaching both affinity ligands and radionuclides to a biomolecule (i.e. preformed and post-formed labeling approaches) in accordance to the routes shown in Scheme II. For therapeutic applications, a preferred method of blood clearance of the new medical agent (conjugated biomolecule), using extracoporeal immunoabsorptive columns is disclosed.

Detailed Description

General structure of compounds disclosed. The chemical nature of a compound for concurrent conjugations of an affinity ligand and an effector agent is shown graphically in the schematic structure (I). A brief description of the various parts of the generalized formulation is provided in the text following the schematic structure (I):



The term "affinity ligand" used throughout the description and the claims means any moiety that binds with another molecule with an affinity constant of 10^6 M^{-1} or higher. A preferred bffinity ligand is a biotin moiety which can be biotin, or any derivative or conjugate of biotin that binds with avidin, streptavidin, or any other biotin binding species.

The term "effector agent" used throughout the description and the claims means a radionuclide binding moiety with or without the radionuclide, a synthetic or naturally occurring toxin, an enzyme capable of converting pro-drugs to active drugs, immunosuppressive or immunostimulating agents, or any other molecule known or found to have a desired effect, directly or indirectly, on cells or tissues.

The term "biomolecule reactive moiety" used throughout the description and the claims means any moiety that will react with a functional group naturally occurring or synthetically introduced on a biomolecule.

The term "trifunctional cross-linking moiety" used throughout the description and the claims means any chemical moiety that can combine the affinity ligand (e.g. biotin moiety), effector agent (e.g. radionuclide binding/bonding moiety) and a biomolecule reactive moiety.

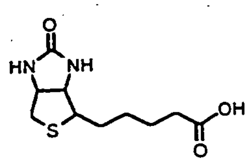
The term "linker 1" used throughout the description and the claims is means chemical moiety that is an attaching moiety and spacer between the trifunctional cross-linking moiety and the biotin moiety such that binding with avidin or streptavidin, or any other biotin binding species, is not diminished by steric hindrance. Linker 1 may also impart increased water solubility and biotinidase stabilization.

The term "linker 2" used throughout the description and the claims means a chemical moiety that is used to attach the radionuclide binding moiety to the trifunctional cross-linking moiety. Linker 2 may also impart increased water solubility.

The term "linker 3" used throughout the description and the claims means a chemical moiety used to attach the biomolecule reactive moiety to the trifunctional cross-linking moiety. Linker 3 may not be required, but may be advantageous in some cases. Linker 3 may be used as a

spacer and/or it may be used to increase the water solubility of the compound.

Affinity ligand . The preferred affinity ligand is biotin or a derivative thereof. In most examples the biotin moiety will be natural biotin 1, which is coupled to linker 1 through an amide bond. In some examples it may be advantageous to have a biotin derivative that does not bind as tightly as natural biotin, or a biotin derivative that binds to chemically modified, or genetically mutated, avidin or streptavidin in preference to natural biotin. Examples of such biotins are norbiotin 2, homobiotin 3, oxybiotin 4, iminobiotin 5, desthiobiotin 6, diaminobiotin 7, biotin sulfoxide 8, and biotin sulfone 9. Other modifications of biotin, including further modification of 2 - 9, are also included.



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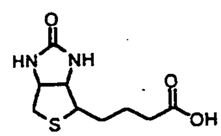

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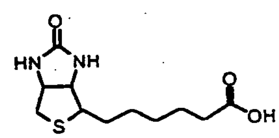

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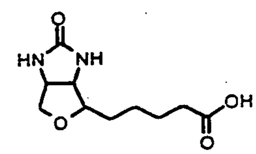

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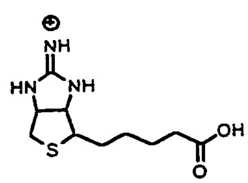

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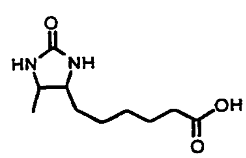

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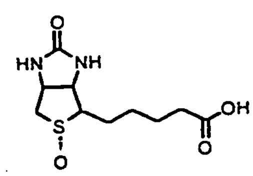

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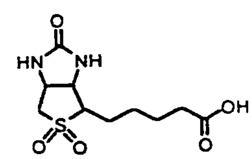

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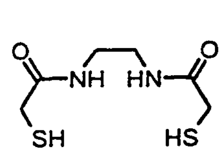
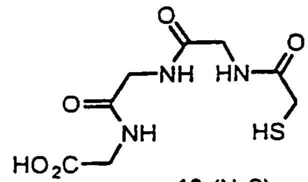
Effector agent. The preferred effector agent is a radionuclide binding/bonding moiety, with or without the radionuclide being present. There are a large number of radionuclides that are potentially useful for diagnostic and therapeutic purposes (see articles in Spencer et al. eds., Radionuclides in Therapy, CRC Press, 1987; Ruth et al., Nucl. Med. Biol. 16, 323-336, 1989), and thus moieties which bind or bond with them may be incorporated as the radionuclide binding/bonding moiety. Examples of

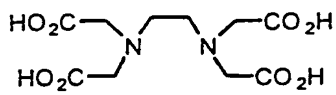
gamma imaging radionuclides include, Tc-99m, In-111, and I-123. Examples of positron imaging radionuclides include, Ga-68, F-18, Br-75, Br-76, and I-124. Examples of therapeutic radionuclides include Y-90, I-131, Re-186, Re-188, Cu-67, Sm-153, Lu-177, Bi-212, Bi-213 and At-211. It is a requirement that the radionuclides be bound by chelation (for metals) or covalent bonds in such a manner that they do not become separated from the biotinylation /radiolabeling compound under the conditions that the biomolecule conjugates are used (e.g. in patients). Thus, the most stable chelates or covalent bonding arrangements are preferred. Examples of such binding/bonding moieties are: aryl halides and vinyl halides for radionuclides of halogens; N_2S_2 9 and N_3S 10 chelates for Tc and Re radionuclides; amino-carboxy derivatives such as EDTA 11, DTPA 12, derivatives Me-DTPA 13 and cyclohexyl-DTPA 14, and cyclic amines such as NOTA 15, DOTA 16, TETA 17, CITC-DTPA (not shown, US patent 4,622,420), and triethylenetetraaminehexaacetic acid derivatives (not shown, see Yuangfang and Chuanchu, Pure & Appl. Chem. 63, 427-463, 1991) for In, Y, Pb, Bi, Cu, Sm, Lu radionuclides. Attachment of the radionuclide binding/bonding moiety to linker 2 can be achieved at a number of locations in the moieties.



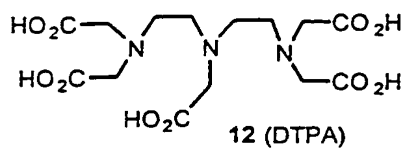
9 (N_2S_2)



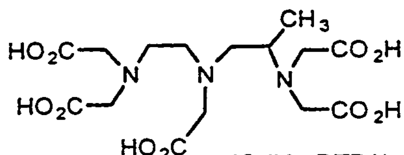
10 (N_3S)



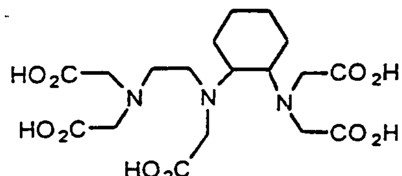
11 (EDTA)



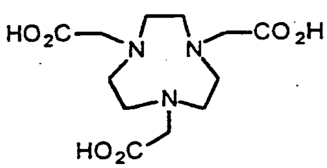
12 (DTPA)



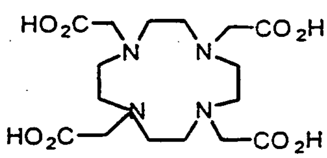
13 (Me-DTPA)



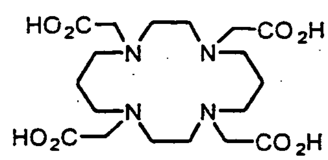
14 (Cyclohexyl-DTPA)



15 (NOTA)



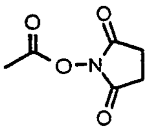
16 (DOTA)



17 (TETA)

Biomolecule reactive moiety. There are a number of moieties that are reactive with functional groups that may be present on a biomolecule, e.g. a protein. For example, aryl or alkyl activated carboxylic acids can be reacted with nucleophilic groups such as primary or secondary amines. Such activated esters include: N-hydroxysuccinimide esters 18, sulfo-N-hydroxysuccinimide esters 19, phenolic esters (e.g. phenol 20, p-nitrophenol 21, tetrafluorophenol 22). Other amine reactive groups include aryl and alkyl imidates 23 and alkyl or aryl isocyanates or isothiocyanates, 24. Sulfhydryl groups on the biomolecule can be reacted with maleimides 25 or alpha-haloamide 26 functional groups. Biomolecules containing naturally or occurring or synthetically produced

(e.g. by conjugation or from oxidized sugar moieties) aldehydes and ketones can be reacted with aryl or alkyl hydrazines 27, aryl or alkyl acylhydrazines 28, alkyl or aryl hydroxylamines 29.



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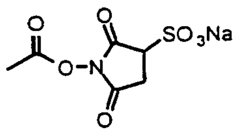

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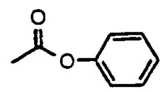

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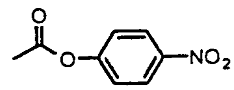

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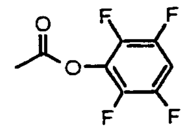

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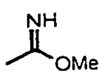

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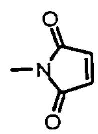

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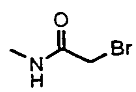

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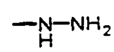

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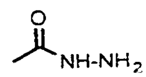

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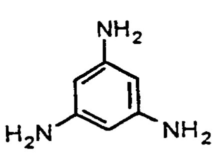
Trifunctional cross-linking moiety. The trifunctional cross-linking moiety has two functional groups that can be used couple with linker 1 and linker 2. It has another functional group that can be either converted directly into the Biomolecule reactive moiety or coupled with linker 3. Examples of preferred trifunctional cross-linking moieties are triaminobenzene, 30, tricarboxybenzene, 31, dicarboxyaniline, 32, and diaminobenzoic acid, 33. If the functional groups present on the cross-linking



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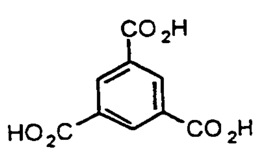

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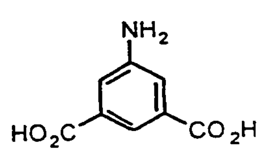

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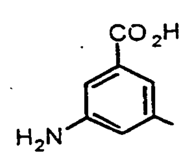

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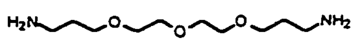
moiety are not by themselves reactive with a functional group on the biomolecule, then they are converted into more reactive moieties, such as activated esters (for carboxylic acids), imidates (cyano functional groups), maleimides (amino), isocyanates, isothiocyanates, etc.

The functional groups present on the cross-linking moiety may vary, and protection/deprotection/activation steps may be required to synthesize the desired compound. A trifunctional cross-linking moiety is preferred, but in those examples where more than one effector agent, affinity ligand, or protein reactive moiety is advantageous, tetrafunctional, or higher, cross-linking moieties may be applied.

Linker moieties. The linker moieties function as spacers and also may aid in water solubilization for compounds that do not contain ionized or ionizable functionalities. Linker 1 must provide ample space between the biotin moiety and the trifunctional cross-linking moiety such that there is a minimum of 9Å for biotin binding with avidin or streptavidin. Extended linkers (e.g. 6 - 20 atoms in length) are preferred to assure that there is no steric hindrance to binding avidin or streptavidin from the biomolecule that the conjugate is attached to. The extended linkers may contain hydrogen bonding atoms such as ethers or thioethers, or ionizable groups such as carboxylates, sulfonates, or ammonium groups, to aid in water solubilization of the Biotin moiety. Many of the Biotin Moieties are highly insoluble in water. When the compounds of this invention are used in serum or in animals or people, there is an additional requirement for a linker attached to biotin that is not required for linkers attached to other moieties. This requirement is to provide a means of blocking the enzyme biotinidase (Wolf et al., Methods Enzymol. 184, 103-111, 1990; Pipsa, Ann. Med. Exp. Biol. Fenn 43, Suppl. 5, 4-39, 1965) from cleaving the amide bond (biotinamide) to release biotin. This requirement is met by altering the distance between the bicyclic rings of the biotin moiety (as in norbiotin or homobiotin) or using a biotin derivative that has a dramatically decreasing binding with avidin or streptavidin (e.g. desthiobiotin). If natural

biotin is used, blockade of biotinidase activity is provided by introducing an alpha carboxylate (Rosebrough, J. Pharmacol. Exp. Ther. 265, 408-415, 1993) or an N-methyl group (Wilbur et al., Bioconjugate Chem. 8, 572-584, 1997) in Linker 1.

Linker 2 must provide a means of coupling an effector agent such as radionuclide binding/bonding moiety with the trifunctional cross-linking moiety. The nature of Linker 2 can be highly dependent on the chemistry associated with effector agent employed, partcularly in the case where the effector agent is a radionuclide binding/bonding moiety. Although linker 2 may be as short as 1 atom, it is preferred to have more space than 1 atom provides to decrease the steric environment around the affinity ligand (e.g. biotin moiety). Linker 2 can also have the water solubilizing atoms or groups of atoms to increase water solubility. Linker 3, if required, provides additional space between the biomolecule and the biotin moiety, and can be used to provide additional water solubilization where required. Examples of preferred non-ionized linkers include the trioxadiamine 34 and dioxadiamine 35. Examples of preferred ionized linkers include aryl diaminosulfonate 36 and aryl diaminotrimethylammonium 37. Examples of linkers that also contain a biotinidase blocking moiety are made by combining one of the linkers 34 - 37 with another molecule, for example combining linker 34 with N-methylglycine to yield linker 38. Where the N-methyl end must be attached to the biotin moiety to impart stability towards biotinidase cleavage.



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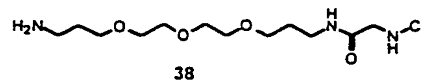

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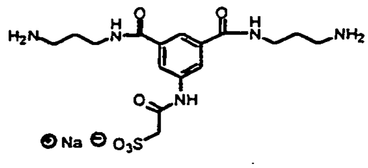

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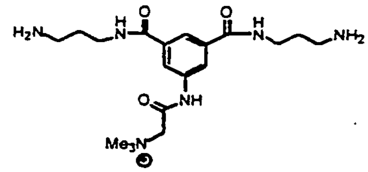

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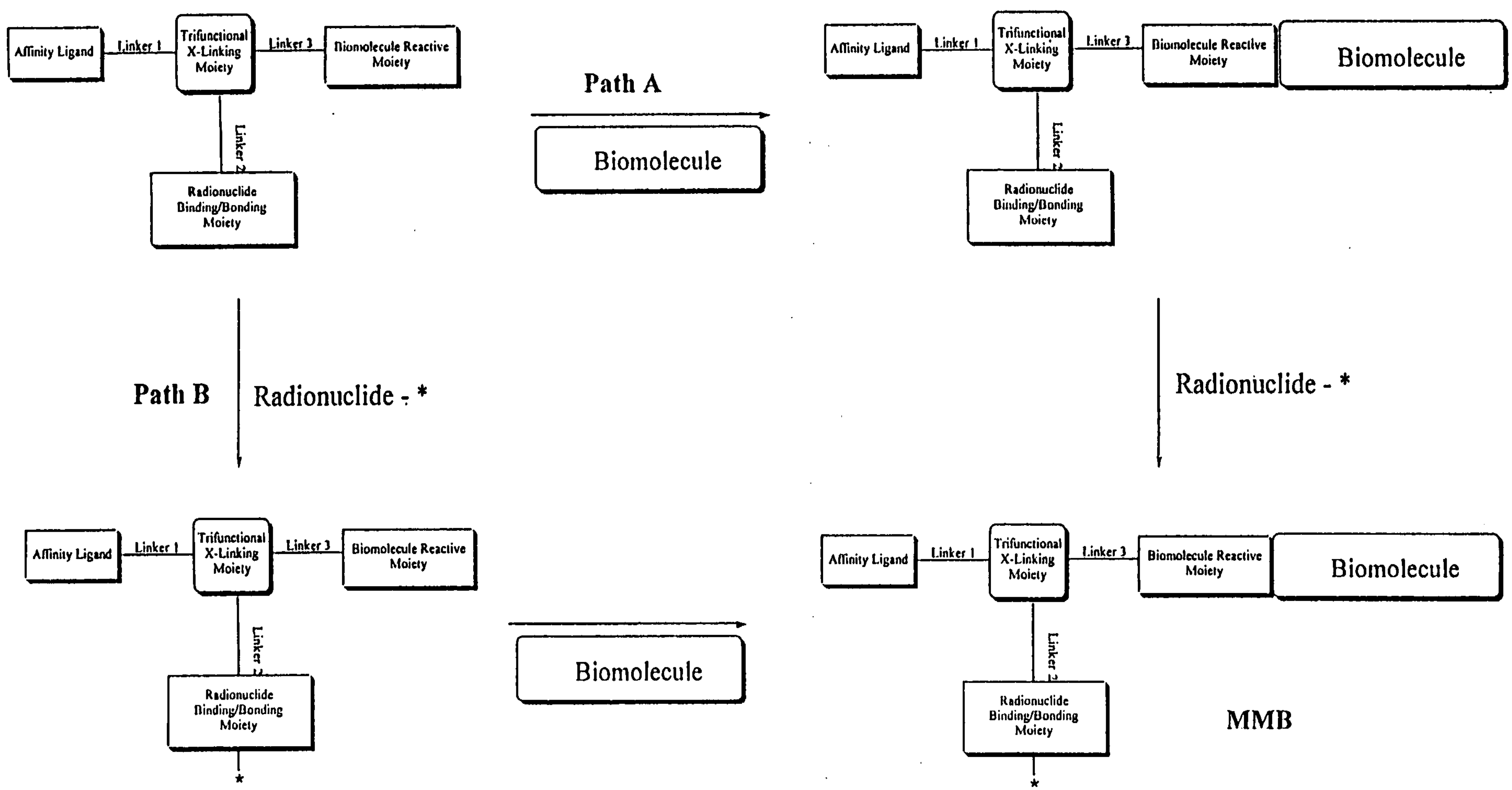
This invention discloses new chemical species that are composed of any combination of affinity ligands (e.g. biotin moieties), effector agents (e.g. radionuclide binding moieties), protein reactive moieties, trifunctional cross-linking moiety, and linking moieties. In specific examples, the reagents of this invention (generically shown in schematic structure (I)) provide a means of biotinylation and radiolabeling of biomolecules. This results in a minimally modified biomolecule (MMB). Irrespective of the individual components of the new chemical species, the process of conjugation and radiolabeling can occur by two distinctly different methods to give the same final product (the MMB), as depicted in Scheme(II) below. Path A is termed postformed conjugate(radio)labeling and Path B is termed preformed conjugate (radio)-labeling. Path A, where a compound of this invention is conjugated with the biomolecule first, and subsequently radiolabeled with the radionuclide chosen, is the preferred method of conjugation and radiolabeling. However, some radionuclide binding/bonding conditions are not compatible with certain biomolecules, therefore, Path B may be used as an alternative approach.

Scheme 2

Radiolabeling and Biomolecule Conjugation Paths



EXAMPLES

The following examples 1-6 are provided to show some of the different combinations of reagents that are disclosed herein, and to show methods for preparing them. The examples are provided by way of illustration, not by way of limitation. Many further examples can be made by differing combinations of chemical moieties as depicted in the general formulation. The examples 1-6 are followed by reaction schemes relating to each example for the production of the reagents 39-44 according to the present invention.

Example 1

Compound 39 is a reagent according to the present invention and contains biotin as the biotin moiety; a biotinidase stabilized linker as linker 1; aminoisophthalic acid as the trifunctional cross-linking moiety; a CHX-DTPA group as a chelator for In-111 and Y-90; an aminobenzyl group for linker 2; no linker 3; and an isothiocyanate biomolecule reactive moiety. A method for synthesizing 39 from previously known reagents is provided.

Example 2

Compound 40 is a reagent according to the present invention and contains biotin as the biotin moiety; a biotinidase stabilized (N-methyl) linker as linker 1; aminoisophthalic acid as the trifunctional cross-linking moiety; a tri-*n*-butylstannylbenzoate group as a moiety that is rapidly reacted to bond with the radiohalogens Br-75/76/77, I-123/124/125/131, or At-211; a trioxadiamine for linker 2; no linker 3; and a tetrafluorophenyl ester biomolecule reactive moiety. A method for synthesizing 40 from previously known reagents is provided.

Example 3

Compound 41 is a reagent according to the present invention and contains this invention and contains homobiotin as the biotin moiety; a trioxadiamine linker as Linker 1; aminoisophthalic acid as the trifunctional cross-linking moiety; an acid labile protected N_2S_2 group as a chelator for Tc-99m or Re-186/188; an propionate moiety for linker 2; no linker 3; and a tetrafluorophenyl ester biomolecule reactive moiety. A method for synthesizing 41 from previously known reagents is provided.

<u>Example 4</u>

Compound 42 is a reagent according to the present invention and contains homobiotin as the biotin moiety; a trioxadiamine linker as linker 1; aminoisophthalic acid as the trifunctional cross-linking moiety; a BAT group as a chelator for Tc-99m or Re-186/188; a pentyloxybenzoate group for linker 2; no linker 3 and a tetrafluorophenyl ester biomolecule reactive moiety. This example is shown in that the BAT chelate allows the reagent to be coupled with a biomolecule (e.g. protein) prior to attaching the radionuclide. Modification Path A. A method for synthesizing 42 from previously known reagents is provided.

<u>Example 5</u>

Compound 43 is a reagent according to the present invention and contains biotin as the biotin moiety; a biotinidase stabilized linker as linker 1; aminoisophthalic acid as the trifunctional cross-linking moiety; a TETA group as a chelator for Cu-67; an amibenzyl group for linker 2; no linker 3; and an isothiocyanate biomolecule reactive moiety. A method for synthesizing 43 from previously known reagents is provided.

Example 6

Compound 44 is a reagent according to the present invention and contains biotin as the biotin moiety; a biotinidase stabilized linker as linker 1; tricarboxybenzene as the trifunctional cross-linking moiety; a tri-*n*-butylstannylbenzoate moiety for reaction with radiohalogens; a trioxadiamine moiety for linker 2; a trioxadiamine moiety for linker 3; and a maleimide group as the biomolecule reactive moiety. A method for synthesizing 44 from previously known reagents is provided.